Process

Introduction

There are three main process functions available: Spatial Filters, Morphology and Histogram. These functions are used to prepare data for further segmentation and analysis.

Spatial Filters

There are 19 different spatial filters that can be applied to a data set. These are described in the table below. A filter can be applied to the entire volume or to selected objects if an object map is loaded.

Filter Type	Description	Method
Low Pass	dampens noise, smoothes volume	replaces the value of each voxel with the average value of the neighborhood*
Unsharp	eliminates homogeneous regions, highlights edges and noise	subtracts a low pass filtered volume from the original volume
Unsharp Enhance	combines unsharp with original volume	adds an unsharp filtered volume to the original volume
Sobel	highlights edges	performs a classic edge detection filter
Sobel Enhance	combines Sobel with original volume	adds a Sobel filtered volume to the original volume
Median	dampens noise, smoothes volume	replaces the value of each voxel with the average value of the neighborhood*
Rank	generic rank filter	orders all the values of voxels in the neighborhood* and returns the value corresponding to the rank in the ordered list†
Sigma	smoothes noise while preserving edges and thin lines	replaces the value x of each voxel with the average value of voxels in the neighborhood* having values of $x \pm 2\sigma$ ‡
VSF Mean	smoothes noise while preserving edges and thin lines	replaces the value x of each voxel with the average value of voxels in the neighborhood§ having values of $x \pm \sigma$
Gradient	highlights edges	replaces the value of each voxel with the maximum absolute difference between its value and that of its orthogonal neighbors

Filter Type	Description	Method
AHE	enhances contrast for viewing (not for measurement)	adjusts voxel values based on histogram of a localized region¶
Anisotropic	reduces noise while preserving edges	performs 2D affine, unbiased or biased anisotropic diffusion for the number of iterations and time per iterationll specified
Convolution	smoothes noise, resulting in a blurry image	performs spatial convolution of volume with user-supplied point spread function
Inhomogeneity Correction	corrects low-frequency grayscale gradients	replaces voxel intensity with I_i * global mean / local mean, where I_i is the input voxel intensity
Sticks	suppresses noise while enhancing thin edges	applies directional masks and determines output based on Type parameter
Chamfer Distance Map	creates a map that may be used for shape recognition	calculates Chamfer distance of each voxel to nearest nonzero voxel
Euclidean Distance Transform	creates a map that may be used for shape recognition	calculates Euclidean distance of each voxel to nearest nonzero voxel
Adaptive Restoration	reduces noise using an adaptive method	degrades image by constant-power additive noise, then applies a low pass filter
Curvature	creates a map of instantaneous local surface curvature	sums binary voxel values in the 26-connected neighborhood of each voxel to give a curvature value from 0-26

*The neighborhood around each voxel is defined by the kernel dimensions selected in the Kernel Size options.

†The kernel size determines the number of voxels whose values are ranked, e.g. a 3 X 3 X 3 kernel has 27 voxels, a 5 X 5 X 5 kernel has 125 voxels and a 7 X 7 X 7 kernel has 343 voxels. The larger the kernel size, the more computationally intensive this filter becomes. It is recommended to use a smaller kernel size such as 3 X 3 X 3. In a 3 X 3 X 3 kernel, a rank of 1 would return the minimum value, a rank of 14 would return the median value and a rank of 27 would return the maximum value.

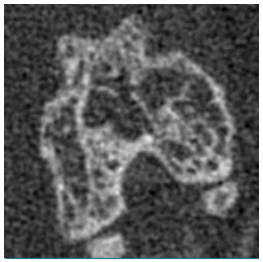
‡If fewer than 9% of the voxels in the kernel fall within the $x \pm 2\sigma$ range, the voxel in question will not be changed. Sigma (σ) is defined using the text box or slider bar.

§The circular neighborhood around each voxel is specified by the Ring parameter.

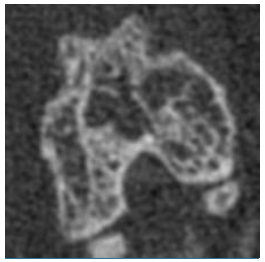
¶Clip Fraction — Specifies the limit of contribution of any given grayscale value, reducing the enhancement of noise in the resulting image or volume. This method is particularly effective for images which have subtle detail in both very bright and very dim regions of the image. It may also be used to expand the dynamic range of grayscale in a region which has subtle but significant changes.

||A value of 0.25 is recommended for general use and will be used as the default if the supplied value is zero or negative. However, a value of 0.10 or less is required to guarantee stable behavior. The lower value will require more iterations but should be used if absolutely correct results are essential. This option is only available when Type is set to Affine.

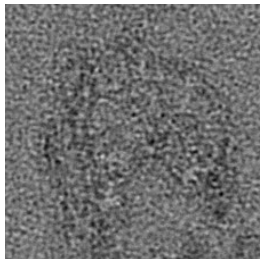
No Filter



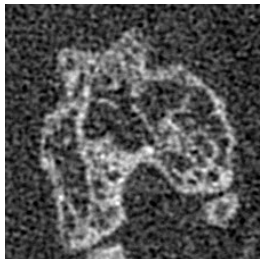
Low Pass



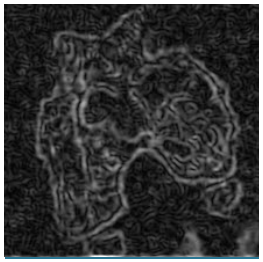
Unsharp



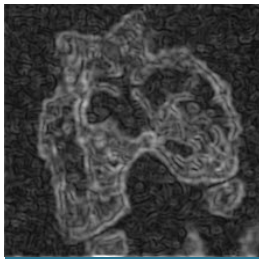
Unsharp Enhance



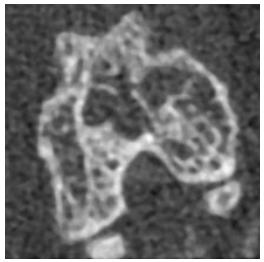
Sobel



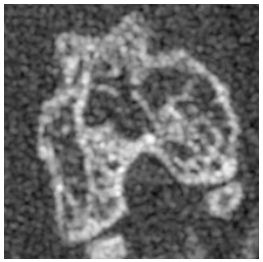
Sobel Enhance



Median

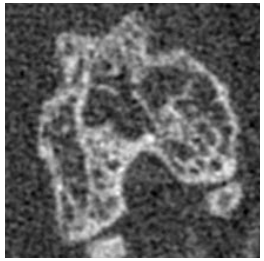


Rank

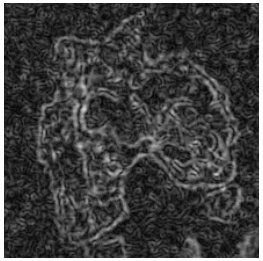


Sigma

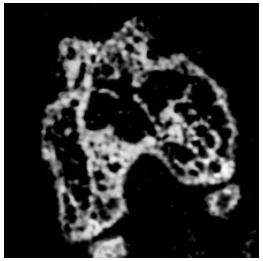
VSF Mean



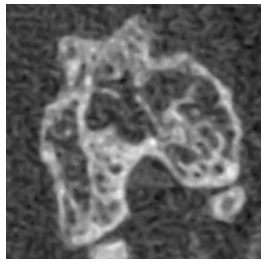
Gradient



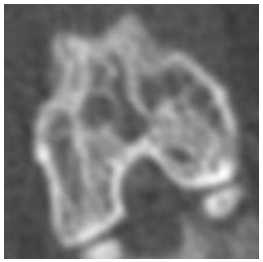
AHE



Anisotropic

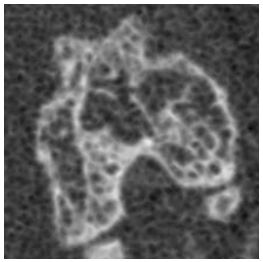


Convolution

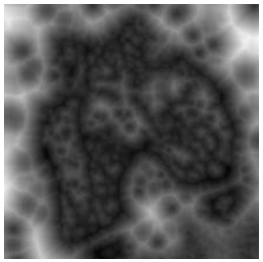


Inhomogeneity Correction

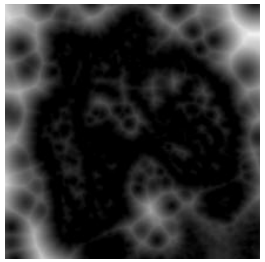
Sticks



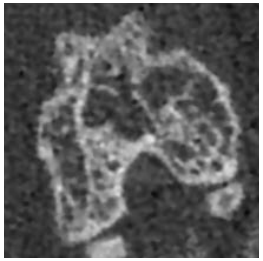
Chamfer Distance Map



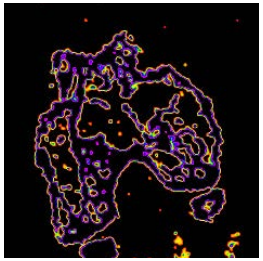
Euclidean Distance Map



Adaptive Restoration



Curvature



1. Applying a Filter to a Data Set

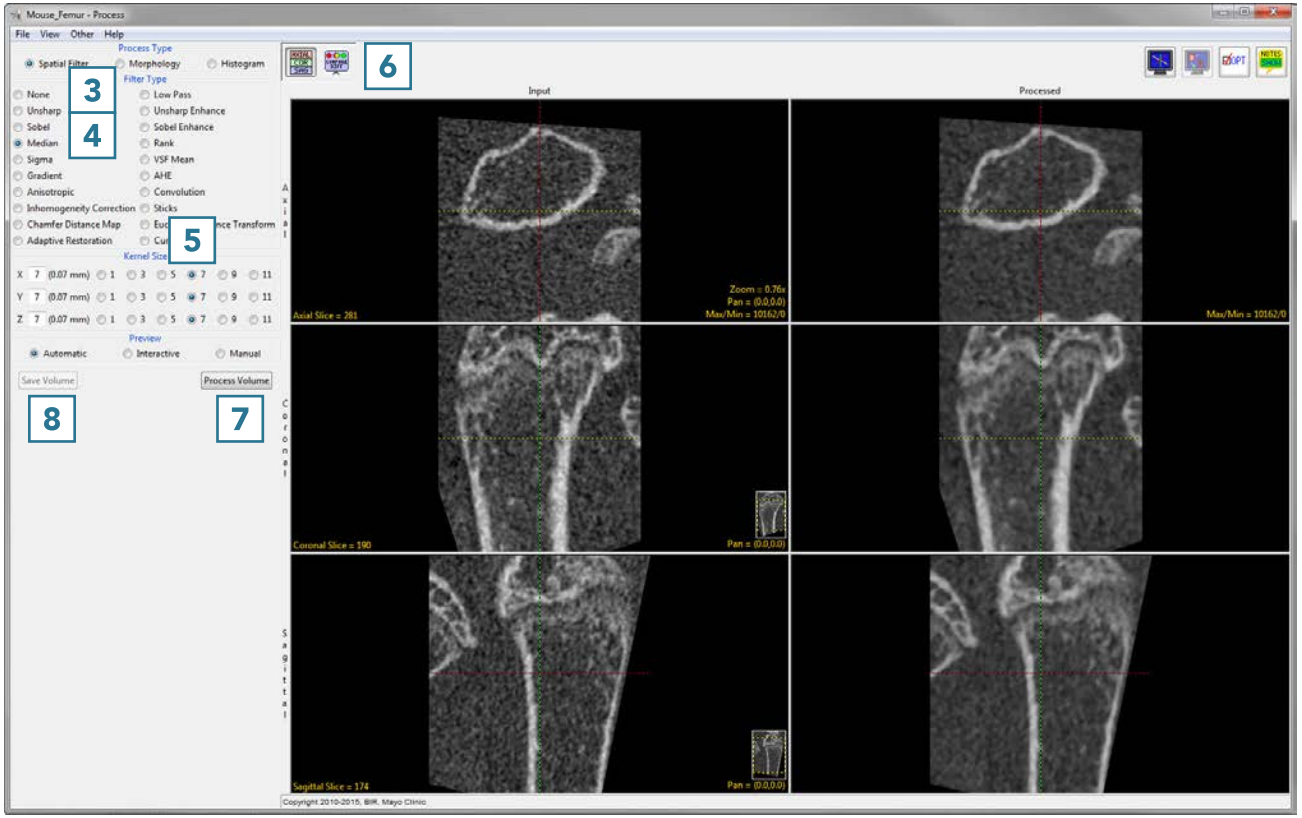
This exercise will show how to apply a median filter to a microCT bone data set.

- Select the data set in the AnalyzePro workspace 1 and open Process. 2

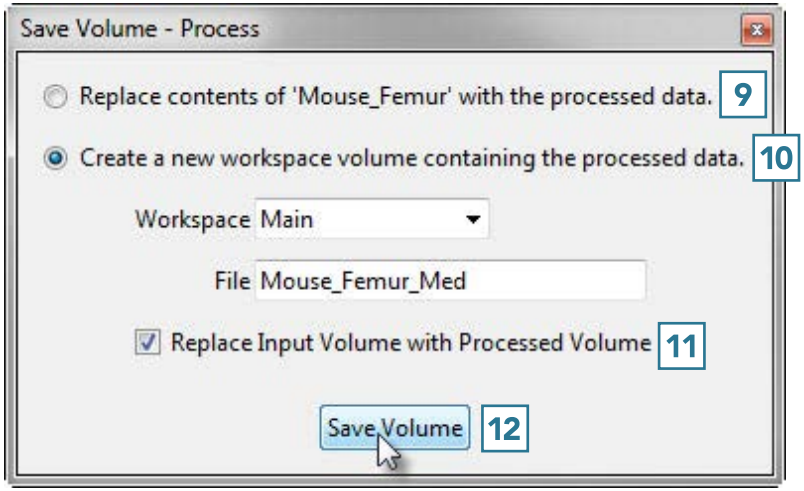
Download the Mouse_Femur data set to follow along http://analyzedirect.com/data/

- Choose Spatial Filter as the Process Type. 3
- Choose a Filter Type. 4 Low Pass and Median filters are commonly used to smooth noisy data.
- Set the Kernel Size in the X, Y and Z dimensions. 5 A kernel size of 7 X 7 X 7 is often used for microCT data acquired using a PerkinElmer scanner.
- To toggle the Compare view, use the Compare Diff button. 6

- Click Process Volume. 7
- Once the processing is complete, the Save Volume button will become available. Click Save Volume. 8



- In the Save Volume window, choose to replace the input data set with the processed data set 9 or to create a new data set. 10
- The new data set can be saved in any workspace in the current project and renamed in the File checkbox. Check the Replace Input Volume with Processed Volume box if you want to further process the processed volume. 11
- Click Save Volume. 12



Morphology

A number of morphologic operations are available, as described in the table below. These operations can be performed on the entire volume or on selected objects if an object map is loaded.

Morphologic Operation	Description	Method
Threshold	isolates structures defined by a difference in intensity	sets voxels between and equal to the specified maximum and minimum to 1 and all other voxels to 0
Erode	peels a layer from the outer edge of large objects and deletes small objects	retains voxels in inner areas of the object, as determined by the structuring element dimensions and shape
Dilate	expands small objects in a binary volume	adds voxels to outer areas of the object, as determined by the structuring element dimensions and shape
Open	removes small objects and breaks isthmuses	erosion followed by dilation
Close	fills thin gulfs and small holes	dilation followed by erosion
Maximum	emphasizes high-intensity regions	grayscale equivalent of binary dilation
Minimum	emphasizes low-intensity regions	grayscale equivalent of binary erosion
Ultimate Erosion	shows the last voxels remaining of disconnected components	performs successive erosions on the object until the last erosion before the components would disappear
Thinning	thins an object in binary or grayscale	thins the object based on the number of iterations specified, using template matching

Morphologic Operation	Description	Method
Homotopic Thickening	thickens an object in binary or grayscale	thickens the object based on the number of iterations specified
Fill Holes	fills holes in a volume	fills holes in 2D or 3D, based on the connectivity value chosen
Connected Components	finds connected regions in a volume	performs a 2D or 3D connected component analysis
Complement	generates inverse of an image	generates the binary or grayscale complement of the image
Umbra	darkens the image	decreases the intensity value of all voxels by the specified intensity cutoff value
Nonmax Suppression	shows voxels of highest intensity	sets voxels which are not at a local maximum to zero
Watershed	performs classic watershed operation	thresholds a binary volume, performs repeated erosions, sets voxels to erosion level and connects components

Histogram

The available histogram operations are Flatten, Preserve, Normalize and Match. These operations can be performed on the entire volume or on selected objects if an object map is loaded.

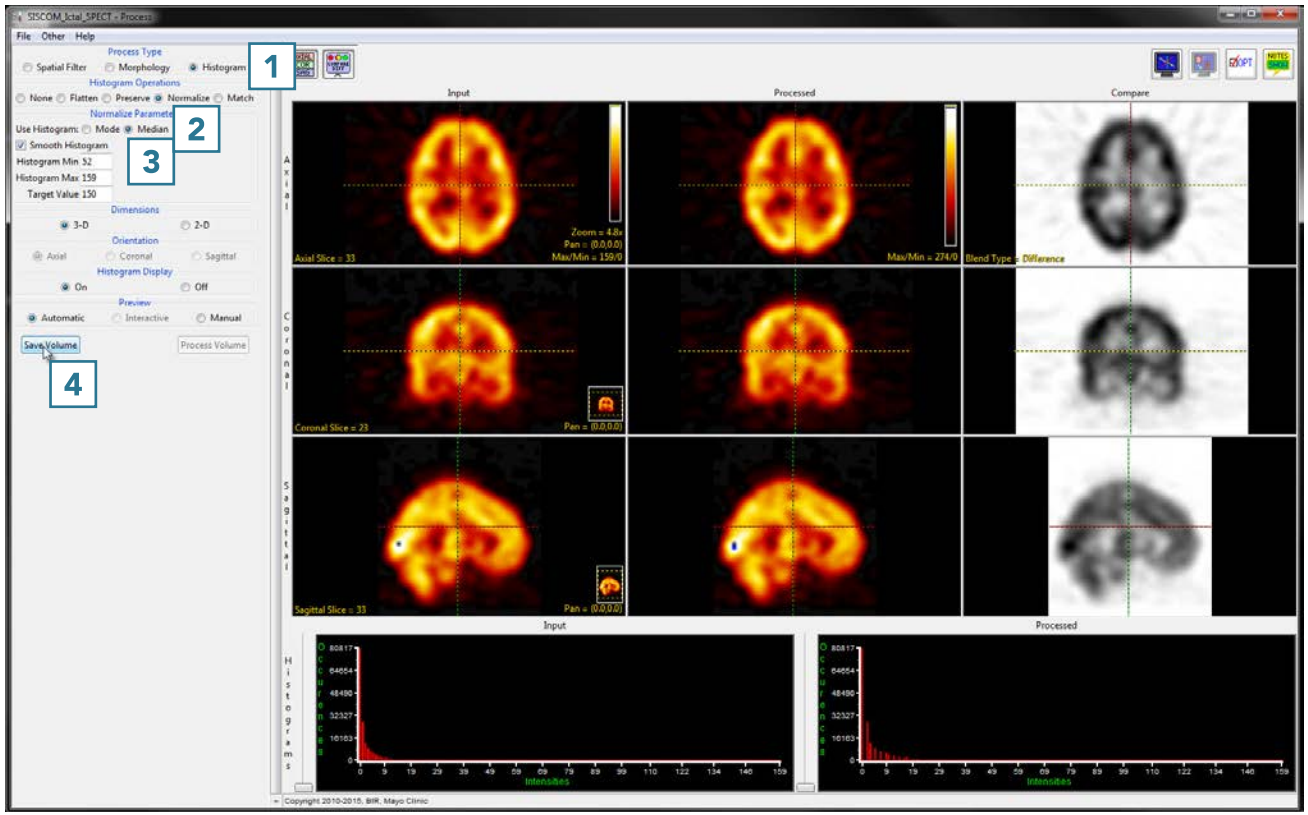
Histogram Operation	Description	Method
Flatten	maximizes contrast	evenly distributes voxels across the specified intensity output range
Preserve	brightens image while preserving contrast	maps the input intensity range onto a narrower output range in a statistically optimal manner
Normalize	allows comparison of data sets	forces the mean or mode of the histogram to specified values
Match	allows comparison of data sets	matches the intensity distribution to a loaded histogram file or the histogram of another volume

2. Histogram Normalization

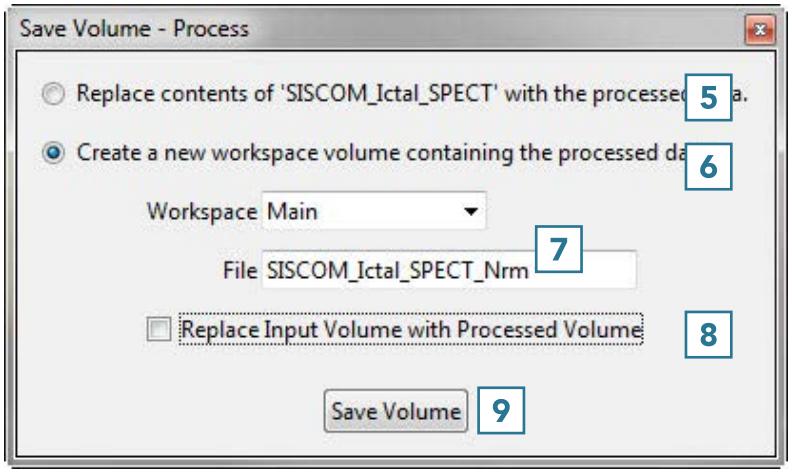
This exercise will show how to normalize the histogram of two functional data sets to the same median value so that they can be compared to each other.

- Select the first data set in the main workspace and open Process.
- Set the process type to Histogram 1 and choose Normalize 2 as the histogram operation.
- Set the parameters to use the histogram median and a target value of 150. 3
- Setting the target value of each data set to the same value will allow comparison between the two.
- Click Save Volume. 4

Download the SISCOM_Ictal_SPECT and SISCOM_Interictal_SPECT data sets to follow along http://analyzedirect.com/data/



- In the Save Volume window, choose to replace the input volume with the process volume 5 or create a new workspace volume. 6
- Name the file, if creating a new workspace volume. 7
- If you want to process the volume further, choose to replace the input volume with the process volume. 8
- Click Save Volume to apply the changes. 9



Repeat these steps with the other data set. Once both data sets are normalized to the same median value, they can be subtracted to create a difference map or otherwise quantitatively compared.